

cervical-to-trochanteric ratio was 1:1.30 [7]. The right hip was fractured in 47 patients and the left hip in 38 patients. The average age was 81.4 years old, which was the highest among the four kinds of fractures, with a range of 18 to 97 years old. Of 44 random hip fracture patients for whom we were able to examine a spinal X-ray, 81.8% (36 of 44) also had a vertebral fracture [7].

#### Distal radius fracture

There were 76 cases of fracture of the distal radius (18 males and 57 females, with 1 case of unknown gender): a male-to-female ratio of 1:3.2. The incidence per 100000 population per year was 108.6 [8]. Adjusted for the Japanese population, the incidence was 76.9. Thirty-four fractures occurred on the right side and 42 on the left side. The average age at the time of injury was 60.2 years old, with a range of 8 to 91 years old.

#### Proximal humerus fracture

There were 26 cases of fracture of the proximal humerus (3 males and 23 females), a male-to-female ratio of 1:7.7. The incidence per 100000 population per year was 37.1 [8]. Adjusted for the Japanese population, the incidence was 37.3. Nine fractures occurred on the right side, 16 on the left, and 1 occurred bilaterally. The average age at the time of injury was 75.7 years old, with a range of 15 to 92 years old.

#### Overall incidence of fracture

Incidence for the four kinds of fractures are shown in Table 1. We identified 350 fractures, including the vertebra, hip, distal radius, and proximal humerus, giving a total incidence of these fractures of 499.9 per 100000 population per year. The average age at the time of injury was highest for fractures of the hip (81.4 years old), followed by the vertebra (77.7 years old), proximal humerus (75.7 years old), and distal radius (60.2 years old). The incidence of each fracture by age is shown in Fig. 2: fractures of the vertebra, hip, and proximal humerus steeply increased in the seventies or eighties. A similar increase in incidence for fractures of the distal radius was not observed. The incidence of each fracture and the average age for males and females are also

shown in Table 2: both the incidence and age at the time of injury were higher in females for all fractures.

The incidences of each fracture by age in males and females are shown in Fig. 3. These data show a peak in fractures of the distal radius in the male teens, whereas the incidence of fracture gradually rose in females with age and then decreased after the seventies. Very few fractures of the proximal humerus occurred in males, whereas a peak was present in the nineties in women. For vertebral fractures, the incidence gradually increased from the sixties and reached a peak in the nineties, without a large gender difference. The incidence of hip fractures began to increase from the seventies, with an exponential increase in women.

#### Place and cause of injury

The location in which each fracture occurred is shown in Fig. 4. Outdoor injuries were most common for fractures of the distal radius, followed by the proximal humerus, vertebra, and hip. Based on data for each kind of fracture, as the average age at the time of injury increased a greater percentage of injuries occurred indoors (Fig. 4). As shown in Fig. 5, the most common cause of injury was a fall, but there were many divergent causes of vertebral fracture.

#### Hospitalization and outcome after discharge

The average period of hospitalization and the places to which hospitalized patients were discharged are shown in

Incidence per 100 000 person-year

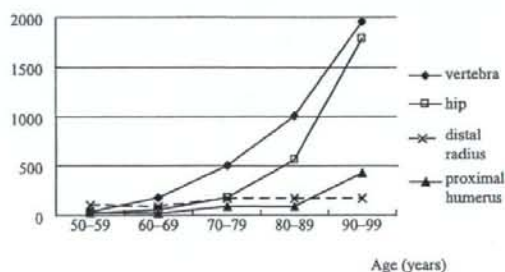
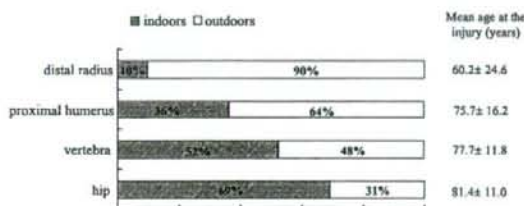
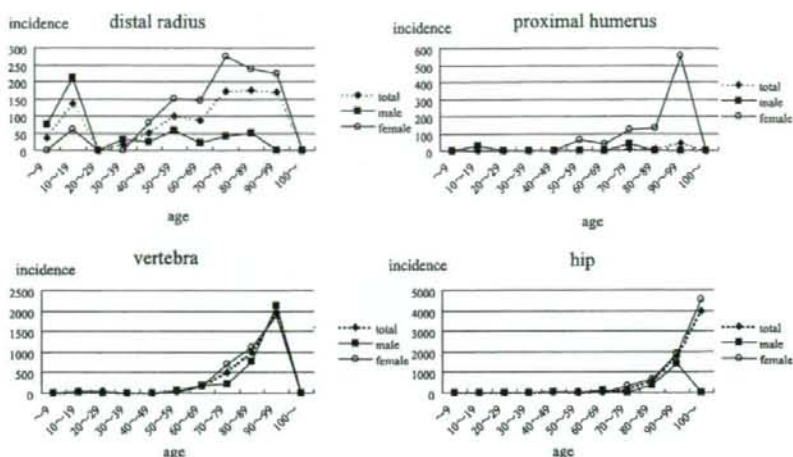


Fig. 2. Incidence of each type of fracture by age in years

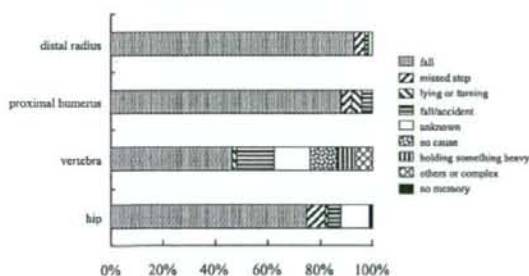
Table 2. Incidence of each fracture in men and women

Site	Males			Females		
	Number of fractures	Incidence (per 100000 person-year)	Mean age (years)	Number of fractures	Incidence (per 100000 person-year)	Mean age (years)
Vertebra	45	134.7	75.0 ± 13.7 (18-96)	118	322.5	78.7 ± 10.9 (19-97)
Hip	20	59.8	75.2 ± 15.9 (42-94)	65	177.6	83.3 ± 8.2 (56-101)
Distal radius	18	53.9	36.0 ± 27.7 (8-82)	57	155.8	69.1 ± 16.7 (11-91)
Proximal humerus	3	9.0	57.3 ± 36.7 (15-79)	23	62.9	78.2 ± 11.2 (56-92)
Total	86	257.3	—	263	718.7	—

**Fig. 3.** Incidence of each type of fracture by age in years for males and females



**Fig. 4.** Place where injury occurred, by each type of fracture: indoors or outdoors



**Fig. 5.** Cause of injury leading to fracture

Fig. 6. Of patients with a fracture of a vertebra, 87% were discharged to home, whereas only 55% of patients with a hip fracture were discharged to home and 36% were transferred or discharged to a nursing home. The average hospitalization period was 30.5 days for a hip fracture and 20.4 days for a vertebral fracture.

#### Drugs taken before injury

The percentage of patients taking agents for osteoporosis before the injury is shown in Fig. 7. In most cases of hip

and vertebral fractures, the patients did not take any anti-osteoporosis medicine before the injury occurred.

## Discussion

The key aspect of the study was to examine all major osteoporosis-related fractures over a defined period of time in a limited area. Our results showed that there were 350 fractures (499.9 fractures per 100 000 population per year), including fractures of the vertebra, hip, distal radius, and proximal humerus, in Sado City in 2004. Vertebral fractures were most common, followed by fractures of the hip, distal radius, and proximal humerus; for the last three fractures, this order is similar to those found in past surveys in Japan [9–12]. Concerning vertebral fractures, previous surveys of the Japanese population have found an incidence of 4000 per 100 000 person-years (PY) for women in their seventies and 8400 per 100 000 PY for women in their eighties [13]. A study in Europe found an incidence of 920–977 per 100 000 PY for women of all ages [14]. Our survey showed an incidence of 322.5 per 100 000 PY for all women and 1117 per 100 000 PY for women in their eighties. Therefore, our incidence rate was lower than those found in previous studies, which may be because the survey was carried out in hospital subjects only, and some patients with a vertebral fracture may not consult with a hospital or clinic. Further examination of this issue is needed; however, it seems likely that vertebral fracture has a higher incidence than other kinds of osteoporotic fractures. Furthermore, we found that most hip fracture patients already had a vertebral fracture, suggesting that patients with a vertebral compression fracture have a high risk of a subsequent hip fracture. We note that previous data suggest that the Japanese population have a similar or greater number of vertebral fractures and fewer fractures of the long bone (including the hip and upper extremities) compared to European and American Caucasian populations [6,10,15–17].

Fig. 6. Outcome of hospitalized patients after discharge. Average hospitalization period in the orthopedic ward was  $20.4 \pm 10.3$  days for vertebral fractures and  $30.5 \pm 15.9$  days for hip fractures

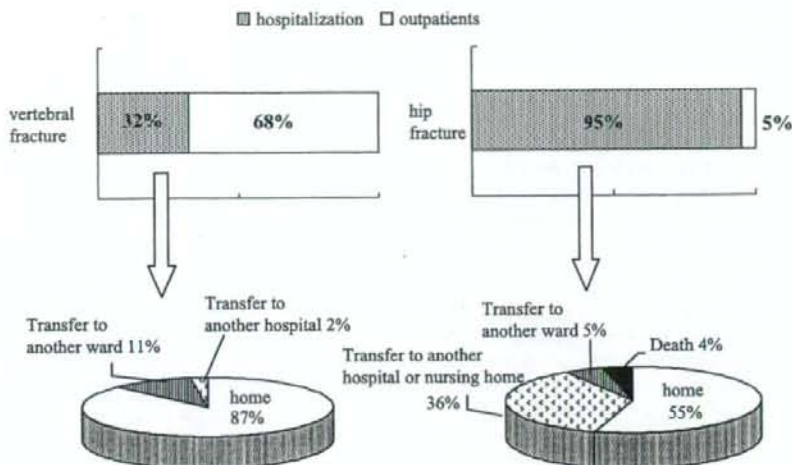
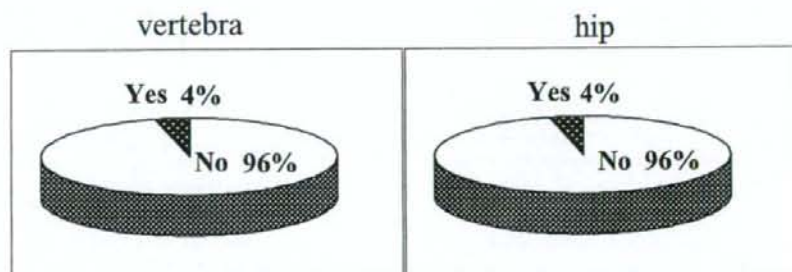


Fig. 7. Most patients who suffered vertebral or hip fracture had not taken anti-osteoporosis drugs before injury



Morita et al. [11] reported that the incidence of hip fractures in Niigata Prefecture in 1999 was 68.2 per 100000 PY, which was double the rate in 1985. In the current study, the incidence in Sado City was higher than all previous reports in Niigata Prefecture (Table 1). Therefore, hip fracture incidence appears to have increased since 1999, perhaps because the proportion of aged persons has increased more in Sado City than in Niigata Prefecture overall. The incidence of fracture of the distal radius in women in our study was lower than that found in Tottori Prefecture in 1995 (211.4 per 100000 PY) [10], but our incidence of proximal humerus fracture was higher than that in the earlier study (47.9 per 100000 PY) [10]. The mean age for injury of the proximal humerus is higher than that of the distal radius, which also suggests that the high aging rate in Sado City (34.0%) might account for these observations.

Our results indicated that the incidence of distal radius fracture increased for people in their fifties onward, but that there was no upward trend in incidence after the eighties (see Fig. 3), possibly because physical activity in the fifties to seventies leads to a higher rate of fracture of the distal radius, whereas reduced physical activity in people above 80 years of age tends to decrease the incidence of this fracture. Fracture of the distal radius may also occur

more frequently in younger persons because such people are more likely to use a hand to protect against a fall, whereas elderly people might hit a hip or shoulder joint directly under such circumstances, thereby accounting for the higher incidence of fractures of the hip or proximal humerus in older people. However, the number of fractures of the radius or humerus was very small in males, and so this argument might not apply to men. The peak incidence of fracture of the distal radius occurred in teenagers in males, which we speculate is mainly the result of accidents.

There were more left-side fractures of both the distal radius and proximal humerus, compared to the right side, although the difference was not significant (distal radius,  $P = 0.358795$ ; proximal humerus,  $P = 0.161513$ ). Previous studies have reported similar results [10,18], and it has been suggested that dextral individuals are predisposed to injury on the opposite side as a consequence of environmental factors, or that there is decreased hand coordination of the left hand relative to the right in right-hand-dominant people [18]. The dominant hand was not checked in the current study, but most of the Japanese population are right handed; therefore, the larger number of left-side fractures is consistent with the expected data.

Injury while indoors was most common for fractures of the hip, followed by the vertebra, proximal humerus, and distal radius. The age at the time of injury decreased in a similar order; that is, the average age was highest for fractures of the hip. Injury indoors tended to increase with age, making it important to focus on prevention of slight falls or injury indoors in elderly people. About half the patients with a hip fracture were able to be discharged to their home. Both physical exercise by rehabilitation and maintenance and practical use of social welfare resources are important to increase the percentage of patients who can return home after hospitalization.

Drugs for osteoporosis were not taken before injury in most cases of hip and vertebral fractures. A past investigation performed on Sado Island indicated that the incidence of hip fracture significantly decreases with vitamin D treatment, compared with a nontreatment group, and that stopping the treatment increased the risk of hip fracture [19]. As it appears that vertebral fracture leads to hip fracture, fracture prevention from an early stage by treatment with drugs should be carried out to reduce the chance of this series of fractures, and preventive treatment should be further encouraged in osteoporotic elderly people.

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## 大腿骨近位部骨折発生率はなお上昇傾向にある

—疫学調査のレビューと考察—

萩野 浩

### はじめに

骨粗鬆症性骨折のなかでも大腿骨近位部骨折は高齢者四肢骨折のなかでも最も頻度が高く、90%以上の症例で手術的治療を要することから、社会的、医療経済的にきわめて重要な位置を占める疾患である。

近年、北欧や北米では大腿骨近位部骨折の発生率が低下していることが明らかとなっている。な

かでも北米では、骨粗鬆症の診断や、骨吸収抑制剤の適切な使用頻度の増加に平行して発生率低下が観察されたと報告されている<sup>1)</sup>。一方、わが国を含めアジア地域では、大腿骨近位部骨折発生率の上昇が続いている<sup>2)</sup>。

本稿ではわが国や海外で行われた、これまでの大腿骨近位部骨折の疫学調査をレビューし、本講演で発表した最近の鳥取県での調査結果につい

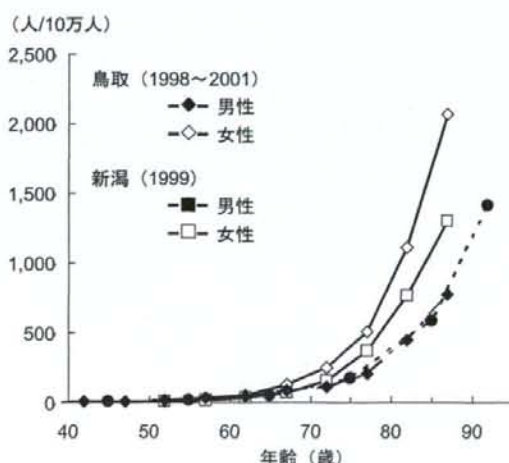


図1 大腿骨近位部骨折の年齢階級別発生率(年間人口10万人あたりの患者数)(文献2, 4より引用・作成)

50歳以下では男女とも人口10万人あたり10以下でその発生はごく少なく、60歳以上で徐々に発生率が増加し、70歳以降に指数関数的に上昇する。

Hip Fracture Incidence Rate is Increasing yet—Review and Consideration of Epidemiologic Surveys—

Hiroshi Hagino : Rehabilitation Division, Tottori University Hospital

Key words : 骨粗鬆症, 大腿骨近位部骨折, 高齢者

鳥取大学医学部附属病院リハビリテーション部部长・診療教授

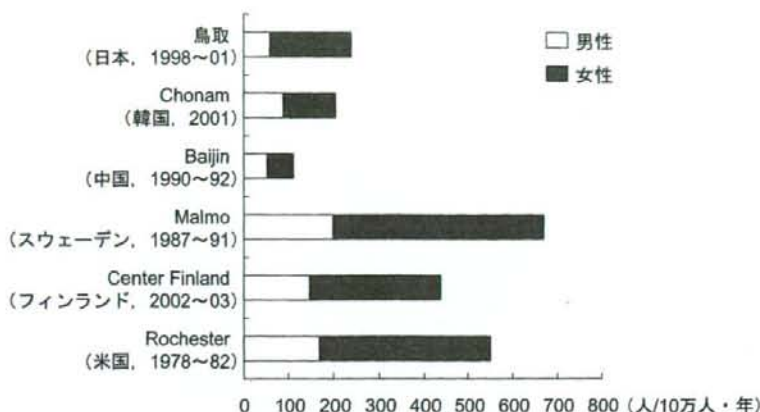


図2 大腿骨近位部骨折発生率の国別比較

これまで報告されている性・年齢階級別の発生率に基づいて、2000年の35歳以上日本人人口構成で補正した、35歳以上の10万人あたりの年間発生数。日本人を含めたアジア人での発生率は、北欧や米国の白人のものより明らかに低値である(文献2, 5~7, 9より作成)。

でも触れる。

### 1 年齢階級別発生率

近年、わが国で行われた調査によれば、大腿骨近位部骨折の発生率は70歳以降に指数関数的に上昇する(図1)<sup>2~4)</sup>。80~84歳では年に約100人に1件、85~89歳では年に約50人に1件、90歳以上では年に約30人に1件の割合で発生する。

### 2 諸外国との比較

これまで報告されている性・年齢階級別の発生率に基づいて、2000年の35歳以上日本人人口構成で補正し、35歳以上の10万人あたりの年間発生数を比較すると、日本人を含めたアジア人での発生率は、北欧や米国の白人のものより明らかに低値である(図2)<sup>5~9)</sup>。この理由の一つが日本人の転倒発生率が欧米白人に比べて低いことであると考えられている<sup>10)</sup>。

### 3 最近の鳥取県での観察結果

鳥取県で2004年1月~2006年12月の3年間に鳥取県下で発生し加療を受けた大腿骨近位部骨折患者を対象に調査を行った。その結果、2004

~2006年の3年間に約2,800例以上(35歳以上)の患者が発生していた。性別では女性が男性の4.4倍で、骨折型別では転子部骨折のほうが多かった。特筆されるのは1986年に比べて2006年の患者数は4倍近くに増加し、性・年齢階級別発生率(人口10万人あたり年間発生数)は1986~2001年の発生率に比較し、上昇傾向が観察されたことである。

### 4 経年的推移

わが国では各地域で過去の調査結果から、年齢階級別の発生率が経年的に上昇していることが明らかとなっている(図3)<sup>2,3)</sup>。同様に、シンガポール、韓国、香港、台湾などのアジア諸国でも発生率が経年的に上昇していると報告されている<sup>8,11~13)</sup>。これに対して北欧や北米、あるいは豪州では、近年、発生率は増加しておらず、一部の地域では減少に転じている<sup>1,14,15)</sup>。

### 5 発生率上昇が意味するもの

これまでの報告からは、発展途上国のように、都市化が急速に進んでいる地域ほど発生率の上昇率が高い。このため、発生率の推移に影響する重要な要因として、身体活動性の低下、飲酒量

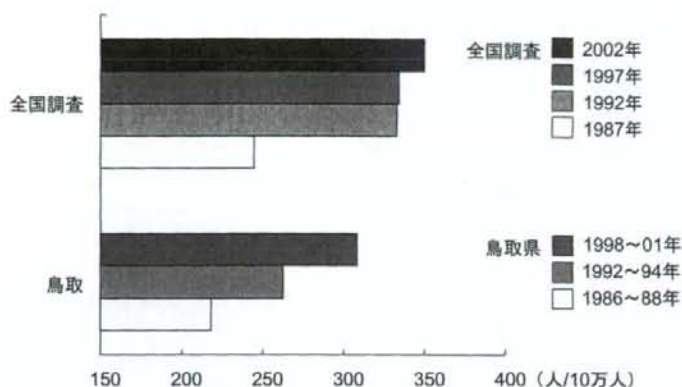


図3 大腿骨近位部骨折の経年的発生率の推移

わが国における最近の発生率より、2000年日本人口構成に基づいて算出した骨折発生数(50歳以上、年間人口10万人あたり)(文献2, 3より引用作成)。

や催眠鎮静剤の服用頻度の増加があげられ、都市化、生活様式の欧米化に伴うこれらの変化が、骨脆弱化の進展や転倒の危険性を高め、骨折発生率上昇の一因となっているのではないかと推測されている。

## 6 将来予測

発表されている日本人の将来人口推計に従い、わが国で報告されている、最近の性・年齢階級別発生率に基づいて計算すると、2007年1年間に約16万例の大腿骨近位部骨折が発生すると推計される。この新規骨折発生数は高齢者人口の増加に伴い、2030年には年間26~30万人に達すると予想される。さらに、30年後には90歳以上の患者数が、80歳台の患者数を超え、全患者数の約半分を占めるに至る。

## おわりに

大腿骨近位部骨折の予防効果を有する骨粗鬆症治療薬が開発され臨床現場で使用できるようになって久しい。それにもかかわらず、大腿骨近位部骨折の発生率に歯止めがかかっているのが現状である。現在1,100~1,200万人と推計される骨粗鬆症患者のうち、薬物療法を受けているのは20~25%程度と推計され、脆弱な骨格を有す

る高齢者が、高い骨折リスクを抱えて日常生活を行っている。人類が経験したことがない急速な高齢化が進行するわが国において、大腿骨近位部骨折のリスクを的確に診断し、効率のよい治療によって、本骨折の抑制を図ることは、われわれが避けることができない挑戦である。

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# 大腿骨近位部骨折患者の予後

萩野 浩

高齢者人口が急速に拡大しているため、高齢者に好発する骨折患者数も急増している。骨粗鬆化の進展に伴い高齢者では種々の骨折が発症するが、その中でも脊椎骨折、大腿骨近位部骨折、橈骨遠位部(前腕)骨折、上腕骨近位部骨折の頻度が高く、高齢者の4大骨折と呼ばれる。このうち大腿骨近位部骨折は患者の日常生活動作(ADL)を最も低下させ、生命予後も引き下げる。さらに、保存的治療を選択すれば、長期間の臥床を強いられることとなるため、可能な限り手術的治療が優先される。したがって本骨折は医療経済的にも重要な位置を占めるのである。

## Q1 大腿骨近位部骨折の分類と発生率は？

大腿骨近位部骨折(hip fracture)は頸部骨折(neck fracture)と転子部骨折(trochanteric fracture)とに分けられる(図1)<sup>1)</sup>。これまで大腿骨近

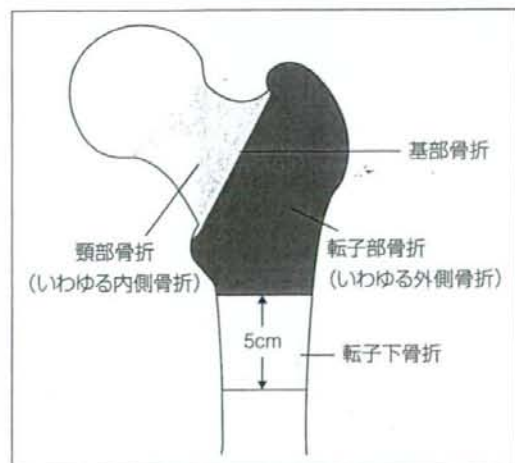


図1 大腿骨近位部骨折の分類 (文献1より抜粋)

位部骨折を「大腿骨頸部骨折」と称し、治療法や予後が異なるため内側骨折(関節包内)と外側骨折(関節包外)の2つの骨折型に分けることが多かった。しかしながら、英語名称に統一するため、最近、頸部骨折と転子部骨折を合わせた骨折は「大腿骨近位部骨折」と定義された。頸部骨折が以前の「内側骨折」にあたり、転子部骨折が「外側骨折」にあたる。

大腿骨近位部骨折は70歳代から加齢とともに指数関数的に上昇する。80歳代前半で年間100人に1例、80歳代後半で50人に1例、90歳以上では30人に1例発生する<sup>2)</sup>。

わが国を含めたアジア諸国では、年齢階級別の発生率が、近年まで経年的に上昇していることが明らかとなっている。これに対して北欧や北米、あるいはオーストラリアでは、最近では発生率が増加しておらず、一部の地域では減少に転じている。

## Q2 骨折によって自立度はどの程度低下するのか？

国内158施設で治療された大腿骨近位部骨折10,992例を対象とした大規模調査によれば、ADLが自立していた症例(介護保険主治医意見書分類でJおよびA)は骨折前に87%であったが、骨折後1年で50%に低下していた(表1)<sup>3)</sup>。これまでの調査結果から、大腿骨近位部骨折後の能力低下には種々の要因が影響を及ぼすが、なかでも年齢、受傷前の歩行能力、認知症の程度が影響を及ぼすことが多くの研究で一致している<sup>4)</sup>。また退院後に自宅に帰った症例(なかでも同居症例)は

施設入所例よりも機能予後がよい。

Randellらは患者対照研究によって、32例の大腿骨近位部骨折患者のquality of life (QOL)の変化を検討した<sup>5)</sup>。その結果、身体機能は受傷以前と比較して受傷3カ月後にSF-36<sup>®</sup>で51%、OPA2で20%程度の低下を認め、同時に骨折患者では社会活動のスコアが低いことが観察された。Balenらも同様に102例の受傷から4カ月間のQOL前向き研究を行い、とくに社会孤立性がQOLを悪化させる要因となっていた<sup>6)</sup>。このように大腿骨近位部骨折の患者では、身体機能の低下と同時に社会性の低下、すなわち社会とのつながりを絶たれることで、QOLが大きく低下する。

### Q3 骨折によってどの程度死亡するのか？

大腿骨近位部骨折患者では受傷後3カ月から半年までの死亡率が高く、受傷1年後の生存率は約80～90%と報告されている<sup>3,7,8)</sup>。90歳以上の超高齢者では生存率はさらに低下し、1年後生存率は70%程度である。骨折患者の死亡率は骨折後1年までが高いが、その後も非骨折者とは差があり、骨折後10年間で死亡率に両者間で2倍の違いがある<sup>8)</sup>。生命予後に影響を与える因子としては、性(男性のほうが不良)、年齢(高齢者ほど不良)、受傷前の歩行能力(低い者ほど不良)、認知症(有するほうが不良)などがある(表2)<sup>4,9)</sup>。治療法別には人工骨頭置換術のほうが、骨接合術より死亡率が高く、おそらく手術侵襲の差によるものと考えられる。

大腿骨近位部骨折の予防効果を有する骨粗鬆症治療薬が開発され、臨床現場で使用できるようになって久しい。それにもかかわらず、大腿骨近位部骨折の発生率に歯止めがかかっていないのが現状である。発表されている日本人の将来人口推計に従い、最近発表されている性・年齢階級別発生率に基づいて計算すると、2007年1年間に約16

表1 大腿骨近位部骨折発生前と1年後の日常生活性レベル (文献3より引用)

日常生活	骨折前 (%)	骨折1年後 (%)
1. 交通機関などを利用して外出する。	24.3	12.7
2. 隣近所へなら外出する。	26.6	14.1
3. 介助により外出し、日中はほとんどベッドから離れて生活する。	18.2	13.4
4. 外出の頻度が少なく、日中も寝たり起きたりの生活をしている。	17.9	9.8
5. 車いすに移乗し、食事排泄はベッドから離れて行く。	6.4	9.1
6. 介助により車いすに移乗する。	4.3	9.4
7. 自力で寝返りをうつ。	0.6	1.5
8. 自力で寝返りもうたない。	0.4	1.6
9. 不明・その他。	0.3	3.1

表2 死亡率に影響を与える因子 (文献9より引用)

因子	オッズ比(95% CI)	p値
年齢 <sup>1)</sup>	1.04(1.03-1.06)	0.0001
認知症	1.28(1.11-1.48)	0.0006
性別 <sup>2)</sup>	0.50(0.35-0.70)	0.0001
心疾患	1.80(1.28-2.54)	0.0008
BMI <sup>3)</sup>	0.95(0.89-0.99)	0.0113
手術2週後の歩行能力	1.29(1.00-1.62)	0.025
骨折の既往	1.50(1.01-2.22)	0.0443

BMI: Body Mass Index

1)80歳以上は悪化させる

2)女性より男性が悪化させる

3)18kg/m<sup>2</sup>より低値であると悪化

万例の大腿骨近位部骨折が発生したと推計される。この新規骨折発生数は高齢者人口の増加に伴い2030年には年間26万～30万人に達する。大腿骨近位部骨折の適切なリスク診断を行い、効率のよい治療により本骨折の抑制を図る戦略が必要である。

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はぎの ひろし  
鳥取大学医学部附属病院リハビリテーション部  
〒683-8504 鳥取県米子市西町 36-1  
Tel : 0859-38-6862 Fax : 0859-38-6589



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E-mail: sd@igaku-shoin.co.jp <http://www.igaku-shoin.co.jp> 振替: 00170-9-96693

## Recent trends in the incidence and lifetime risk of hip fracture in Tottori, Japan

H. Hagino · K. Furukawa · S. Fujiwara · T. Okano ·  
H. Katagiri · K. Yamamoto · R. Teshima

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### Abstract

**Summary** Hip fracture incidence from 2004 to 2006 in the Tottori prefecture of Japan was investigated and compared with previously reported rates. The age- and gender-specific incidence of hip fracture in the Tottori prefecture has not plateaued, as has been reported for populations in Northern Europe or North America.

**Introduction** Recent data from Northern Europe and North America indicate that the incidence of hip fracture has plateaued, whereas most reports from Asia indicate that the incidence is increasing. The aims of this study were to

investigate the recent incidence of hip fracture in the Tottori prefecture, Japan, and to compare it with previous reports.

**Methods** All hip fractures in patients aged 35 years and older occurring between 2004 and 2006 were surveyed in all of the hospitals from the Tottori prefecture. The age- and gender-specific incidence rates were then calculated. Using these and previously reported data, the estimated number of hip fracture patients was determined using the age- and gender-specific incidence rates in each year from 1986 to 2006.

**Results** The survey identified 851, 906, and 1,059 patients aged 35 years and older, in 2004, 2005, and 2006 respectively. The residual lifetime risk of hip fracture for individuals at 50 years of age was estimated to be 5.6% for men and 20.0% for women. The estimated number of patients from 1986 to 2006 showed a significant increase over time for both genders.

**Conclusions** The age- and gender-specific incidence of hip fracture in the Tottori prefecture, Japan has not plateaued for either gender.

H. Hagino · H. Katagiri  
Rehabilitation Division, Tottori University Hospital,  
Yonago, Japan

K. Furukawa  
Department of Statistics,  
Radiation Effects Research Foundation,  
Hiroshima, Japan

S. Fujiwara  
Department of Clinical Studies,  
Radiation Effects Research Foundation,  
Hiroshima, Japan

T. Okano · R. Teshima  
Department of Orthopedic Surgery, School of Medicine,  
Faculty of Medicine, Tottori University,  
Tottori, Japan

K. Yamamoto  
Department of Orthopedic Surgery, Hakuai Hospital,  
Tottori, Japan

H. Hagino (✉)  
School of Health Science, Faculty of Medicine, Tottori University,  
Yonago, Tottori 683–8503, Japan  
e-mail: hagino@med.tottori-u.ac.jp

**Keywords** Epidemiology · Hip fracture · Incidence ·  
Lifetime risk · Osteoporosis

### Introduction

Hip fracture is the most significant osteoporotic fracture in terms of health outcomes, quality of life, and cost. As a result of the aging population, the burden of these fractures on our health care systems is increasing and the absolute number of hip fractures is expected to increase significantly during the next few decades. It has been estimated that the total number of hip fractures worldwide will increase from 1.3 million in 1990 to 2.6 million by the year 2025 and to 4.5 million by the year 2050 [1]. To predict the number of

patients requiring treatment for hip fractures during the coming decades, however, it is necessary to determine whether the number of fractures is rising more rapidly than can be accounted for by demographic changes alone.

A growing number of epidemiological surveys show an exponential increase in the incidence of hip fracture with age among different ethnic groups. In addition, data obtained beginning in the 1990s from Northern Europe [2, 3], North America [4], and Australia [5] indicate that previously observed age-specific increases in the incidence of hip fracture have plateaued. We previously performed a hip fracture survey in the Tottori prefecture and found that the incidence of hip fracture increased from 1986 to 2001; this agreed with most other studies from Asia, which indicated an increase in the incidence of hip fracture over time [6].

To estimate the real burden of this problem, a long-term prospective population-based study specifically examining the age distribution and changes in the incidence rates of hip fracture is essential. There is, however, a paucity of long-term data on the changes in these rates in men and women within defined communities. The aims of this study were to investigate hip fracture incidence rates in the Tottori prefecture from 2004 to 2006 and to compare them with previously reported rates.

## Patients and methods

### Data sources

In 2006, the Tottori prefecture, which is located in midwestern Japan, had a population of 603,987, including 176,255 men and 208,582 women aged 35 years and older. The percentages of the population aged 65 years and older, 75 years and older, 85 years and older, and 90 years and older in 2006 were 24.6% (20.4% of men; 28.4% of women), 12.9% (9.4% of men; 16.1% of women), 3.5% (1.8% of men; 5.0% of women), and 1.4% (0.6% of men; 2.0% of women) respectively.

As previously stated [6], all hip fractures in patients 35 years and older that occurred between 2004 and 2006 were surveyed in all of the hospitals in the Tottori prefecture. This included 30 hospitals with orthopedic or general surgery departments; according to the hospital records, survey registration was performed by the doctors or medical staff in each of these hospitals. Registration information included gender, age, area of residence, date of fracture, type of fracture (neck or trochanteric), and treatment. Patients residing in other prefectures were excluded. Duplication of cases was determined using the patients' ages, dates of fracture, types of fracture, and areas of residence. As previously reported [6], we investigated the data collection methods at the three hospitals with the most hip fracture patients in each year, which covered one-

third of the total number of patients in this prefecture. This confirmed that the methods used to register the patients with hip fractures were consistent with those used in previous observational periods.

The study was approved by the local ethics research committee at the Faculty of Medicine, Tottori University.

### Statistical analysis

The patients were divided into groups according to their age (subdivided into 5-year increments), gender, and fracture type (neck or trochanteric fracture). The age- and gender-specific incidence rates (per 100,000 person years) were calculated based on the population of the Tottori prefecture during each year. Every 5 years in Japan, a national census is performed on 1 October, including in 2005 during the observation period. The age- and gender-specific populations for each survey year were estimated by the Bureau of Statistics of the Tottori prefecture government office according to resident registration records.

To determine recent trends in the hip fracture incidence, a test of trends of proportions in quantitatively ordered samples was used [7]. The age- and gender-specific incidence (per 100,000 person years) from 1986–1988, 1992–1994, and 1998–2001, which we have previously reported [6, 8], were used for this analysis. The expected number of patients, age-adjusted to the population structure from 1986 in the Tottori prefecture (35 years and older), was calculated from the age- and gender-specific incidence rates in each observation year. The overall and slope Chi-squared values were examined. Additionally, we elucidated the influence of the expansion in the elderly population using the age-adjusted incidence in two age groups: 85–89 years old and 90 years and older.

Lifetime risks of hip fracture for 50-year-old men and women in the population were estimated by simple approximation using the incidence data and the age- and gender-specific incidence and life tables for the Japanese population in 2006 released by the Ministry of Health, Labour and Welfare of Japan (<http://www.mhlw.go.jp/english/database/index.html>).

To compute the lifetime risks,  $Pr$  was defined as the probability of having no hip fracture until death for a 50-year-old man or woman. This probability may be discretely approximated using the following formula:

$$\begin{aligned} Pr = & d50(1 - I50) + (1 - d50)(1 - I50)d51(1 - I51) \\ & + (1 - d50)(1 - I50)(1 - d51) \\ & \times (1 - I51)d52(1 - I52) + \dots \end{aligned}$$

where  $d50$  is the probability of dying between the ages of 50 and 51 years,  $I50$  is the probability of having a fracture between the ages of 50 and 51 years, and so on. These

values were replaced with the corresponding incidence or mortality rates in this study. The residual lifetime risk of an individual aged 50 years experiencing a hip fracture is then estimated by  $1 - Pr$ .

The significance of the difference in proportions of patients with left or right fractures was examined using Chi-squared testing. The monthly variation in the number of patients was tested using the Friedman test.  $P < 0.05$  was regarded as significant.

## Results

### Characteristics of patients aged 35 years and older with hip fracture

Registration was performed in all hospitals during the entire observation period. As a result, this survey covered all patients with hip fractures. The survey identified 851 (161 men and 690 women), 906 (170 men and 736 women), 1,059 (191 men and 868 women) patients aged 35 years and older in 2004, 2005, and 2006 respectively. Categorizing the patients by fracture type, there were 360 neck fractures (63 men and 297 women) and 487 trochanteric fractures (97 men and 390 women) in 2004 (4 fractures were undetermined); 338 neck fractures (61 men and 277 women) and 547 trochanteric fractures (103 men and 444 women) in 2005 (21 fractures were undetermined); and 424 neck fractures (84 men and 340 women) and 617 trochanteric fractures (102 men and 515 women) in 2006 (18 fractures were undetermined).

Right hips were fractured in 1,421 patients and left hips were fractured in 1,395 patients, with no significant difference between the numbers of right and left fractures.

The maximum number of fractures occurred in January (267), whereas the smallest number occurred in August (189). There was no statistically significant difference among months during the 3-year period from 2004 to 2006. Including the data from the previous observational periods (1986–1988, 1992–1994, 1998–2001, and 2004–2006), a significant seasonal change in the incidence was noted, with a higher incidence observed in the winter and a lower incidence identified in the summer months ( $p < 0.006$ , by Friedman test).

### Incidence of hip fracture between 2004 and 2006

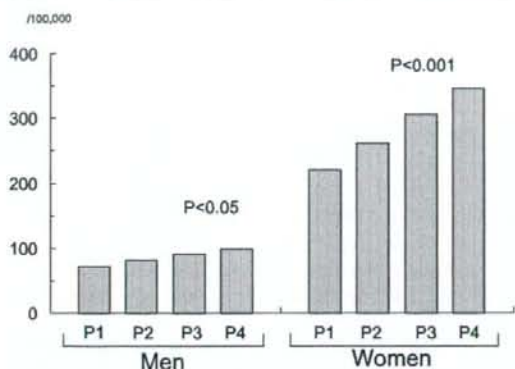
In the population aged 35 years and older, the crude incidence of hip fractures was 244.8 per 100,000 person years from 2004 to 2006, and the gender-specific incidence was 99.1 per 100,000 person years for men and 368.0 per 100,000 person years for women. Although the incidence rate of hip fractures increased with age (Table 1), the absolute number of hip fractures peaked in the 80- to 84-year-old population of men and in the 85- to 89-year-old population of women.

After categorizing the fracture types, the incidence of neck fractures averaged during the 3-year period (from 2004 to 2006) in men and women was 58.6 and 143.7 (70- to 74-year-old group), 101.1 and 309.0 (75- to 79-year-old group), 160.9 and 477.9 (80- to 84-year-old group), 301.6 and 634.7 (85- to 89-year-old group), and 391.5 and 820.1 ( $\geq 90$ -year-old group) respectively. The incidence of trochanteric fractures was 62.9 and 105.5 (70- to 74-year-old group), 128.8 and 244.7 (75- to 79-year-old group), 289.7 and 730.2 (80- to 84-year-old group), 575.4 and 1,470.5 (85- to 89-year-old group), and 619.6 and 2,070.0 ( $\geq 90$ -year-old group) respectively.

**Table 1** Age- and gender-specific incidence of hip fracture in Tottori Prefecture, Japan

Age group (years)	Men						Women						Average	
	2004	n	2005	n	2006	n	2004	n	2005	n	2006	n	Men	Women
35–39	0.0	0	6.0	1	11.5	2	5.9	1	5.9	1	5.7	1	5.8	5.8
40–44	5.8	1	5.8	1	12.2	2	0.0	0	0.0	0	5.8	1	7.9	1.9
44–49	24.9	5	26.0	5	26.8	5	5.0	1	0.0	0	26.5	5	25.9	10.5
50–54	8.5	2	17.6	4	13.7	3	39.2	9	22.6	5	4.7	1	13.3	22.1
55–59	13.4	3	24.8	6	34.6	9	31.6	7	33.5	8	50.7	13	24.3	38.6
60–64	61.3	11	16.6	3	47.1	8	71.6	14	31.0	6	88.3	16	41.7	63.7
65–69	110.7	18	106.4	17	81.7	13	163.7	32	78.8	15	164.4	31	99.6	135.7
70–74	150.8	24	88.6	14	131.5	21	270.3	53	192.9	39	299.2	60	123.6	254.1
75–79	185.5	24	249.0	33	270.6	36	508.0	96	568.7	109	620.8	120	235.0	565.8
80–84	441.8	31	554.9	43	391.7	33	1,163.7	163	1,301.9	196	1,258.3	196	462.8	1,241.3
85–89	665.3	22	915.0	31	1,107.3	39	2,035.8	166	1,953.7	174	2,437.5	230	895.9	2,142.3
90+	1,246.9	20	730.8	12	1,116.7	20	2,605.6	146	3,089.1	183	3,024.6	191	1,031.5	2,906.5

Incidence data are per 100,000 person years



**Fig. 1** Trends in the incidence of hip fracture per annum (patients aged 35 years and older). Data are the expected number of patients adjusted for the age- and gender-specific incidence in each year standardized using the 1986 population structure in the Tottori prefecture. In the population aged 35 and older, 154,774 individuals were men and 183,157 were women in 1986. P1: 1986–1988; P2: 1992–1994; P3: 1998–2001; P4: 2004–2006. The incidence in the periods 1986–1988, 1992–1994, and 1998–2001, which we have previously reported [6, 8], was used.  $\chi^2$  (overall) was 24.7 ( $p < 0.05$ ) for men and 110.0 ( $p < 0.001$ ) for women.  $\chi^2$  (slope) was 16.4 ( $p < 0.01$ ) for men and 97.7 ( $p < 0.001$ ) for women

The residual lifetime risk of hip fracture for individuals aged 50 years was estimated to be 5.6% for men and 20.0% for women.

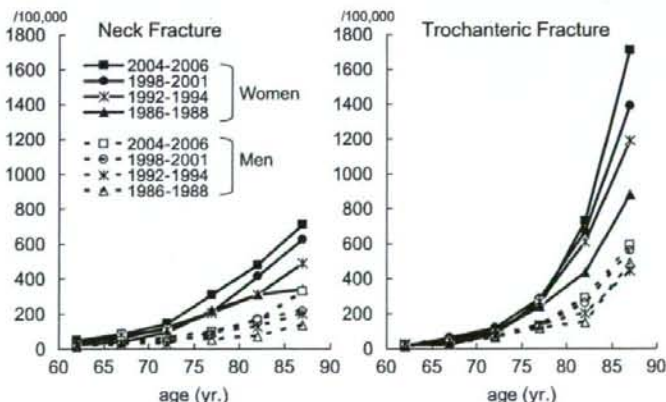
#### Changes in incidence during the 20-year period

During the 20-year observational period, the total population aged 35 years and older in this area grew 1.14-fold, whereas that aged 85 years and older grew 3.18-fold (from

6,662 to 21,163). From 1986 to 1988, 916 hip fractures were reported in patients 35 years and older, whereas 2,816 hip fractures were identified in this patient population in the period from 2004 to 2006. The number of hip fractures among women increased 3.3-fold, from 692 to 2,294, and that among men increased 2.3-fold, from 224 to 522.

The expected number of patients adjusted for the age- and gender-specific incidence in each year and standardized using the population structure of 1986 showed significant increases from 1986 to 2006 for both genders (Fig. 1). The mean age- and female-specific incidence in the 85- to 89- and  $\geq 90$ -year-old age groups was 1,179.2 and 1,506.9 per 100,000 person years from 1986 to 1988, 1,632.8 and 1,838.0 per 100,000 person years from 1992 to 1994, 1,810.9 and 2,407.5 per 100,000 person years from 1998 to 2001, and 2,142.3 and 2,906.5 per 100,000 person years from 2004 to 2006 respectively. Those for men in the 85- to 89- and  $\geq 90$ -year-old age groups were 551.5 and 871.9 per 100,000 person years from 1986 to 1988, 572.6 and 887.3 per 100,000 person years from 1992 to 1994, 632.9 and 1,059.3 per 100,000 person years from 1998 to 2001, and 895.9 and 1,031.5 per 100,000 person years from 2004 to 2006 respectively.

Figure 2 shows the average age- and gender-specific incidence for neck and trochanteric fractures from the periods 1986–1988, 1992–1994, 1998–2001, and 2004–2006. For both genders, the incidence of both types of fracture was significantly higher in 2004–2006 than in all other survey periods. The expected numbers of patients with neck fracture adjusted for the age- and gender-specific incidence in each year and standardized by the population structure of 1986 was 22.0 for men and 87.0 for women in 1986, and 47.2 for men and 175.0 for women in 2006. The expected numbers of trochanteric fractures in men and



**Fig. 2** Age- and gender-specific incidence of neck and trochanteric fractures between 1986 and 2006. Incidence data are per 100,000 person years. Incidence from the periods 1986–1988, 1992–1994, and

1998–2001, which we have previously reported [6, 8], were used for comparison

women were 39.0 and 119.0 in 1986 and 57.0 and 202.2 in 2006 respectively. These increases were statistically significant, with the exception of trochanteric fractures in men.

## Discussion

In this study, we have demonstrated that the age-specific incidence of hip fracture in the Tottori prefecture has not stabilized, but rather has slightly increased during the past two decades. This observational study began in 1986 and has been carried out using 3-year intervals, except for the 4-year survey from 1998 to 2001. The catchment area, the methods of identifying hip fracture patients, and the definitions of fracture were identical to those used in previous studies [6, 8]. The proportion of the population aged 65 years and older in the whole of Japan was 20.8% in 2006, whereas it was 24.6% in Tottori. In the Tottori prefecture, there are 6.6 general hospitals per 100,000 persons (6.2/100,000 persons for the whole of Japan) and the average monthly income is ¥504,729 (US\$4,799) per family unit (¥525,716 [US \$4,997] for the whole of Japan) in 2006. Based on these data, the Tottori prefecture has a higher percentage of seniors, but is representative of Japan based on the medical resources and family economics. Because the Tottori prefecture is on the coast and is surrounded by mountains, all patients with fractures must be treated at a hospital within the prefecture. Japanese citizens are legally obliged to belong to one of several government-subsidized health insurance programs, and thus every patient with hip fracture is treated in a hospital. These circumstances contribute to the validity of this longitudinal survey. The incidence observed during the 20-year period in the Tottori prefecture was in the middle of the range observed within Japan as a whole over the same period [9, 10], suggesting that the data from this study are representative of the Japanese population.

Several studies have suggested a wide geographic variation in hip fracture incidence between countries, with the highest rates reported for northern European countries [2, 3] and the United States [11], and the lowest rates reported in Africa and some Asian populations [6, 12, 13]. The Japanese incidence presented in the current study is slightly higher than that reported recently in Korea [14] or Taiwan [15]. In general, people who live in latitudes farther from the equator seem to have a higher incidence of fracture [16].

The lifetime risk of hip fractures for individuals aged 50 years is estimated to be 22.9% for women and 10.7% for men in Sweden, and 11.4% and 3.1% respectively in the UK [17, 18]. The average life expectancy at birth for Japanese individuals has steadily increased, reaching 78.56 years for men and 85.52 years for women in 2005. The life expectancy for 50-year-old men was 29.26 years and that for women was 35.94 years in 2005. Although the

incidence of hip fracture in Japan is lower than that in Sweden, longer lifespans have elevated the residual lifetime fracture risk for individuals 50 years of age.

This type of increase has been observed in longitudinal data from several areas within Japan [19] and in nationwide surveys [10], in which the incidence was increased in both men and women, particularly among individuals at least 80 years old; the present study demonstrated the same tendency. In the Tottori prefecture, the total population decreased by 2.1% from 1986 to 2006, whereas the population aged 85 years and older more than tripled. This expansion in the elderly population may have affected our findings. To address this possibility, we compared the age-adjusted incidence with previous observations in the population aged between 85 and 89 years and in that aged 90 years and older. We found a substantial increase in women in the incidence in these age groups and in men 85 to 89 years old. This age-specific increase in these older populations indicates that the increase in hip fracture incidence is not completely due to a proportional change in the population structure.

Decreases in the incidence of hip and wrist fractures have been observed in Ontario, Canada; the authors suggested that the higher diagnosis rates for osteoporosis and the shift from specialist to primary care observed in the late 1990s resulted in a greater number of women with osteoporosis receiving appropriate diagnosis and treatment, which coincided with the reduction in fracture rates [20]. A nationwide decline in the incidence of hip fracture has been also reported in Finland; potential reasons proposed by the authors included a cohort effect toward a healthier elderly population, increased body mass index, improved functional ability in the elderly, specific actions to prevent and treat osteoporosis, and effective programs and interventions for fall prevention [21]. Bone mineral density in older Japanese individuals has been increasing recently. The Miyama study conducted in 1990 and in 2000 showed significant improvements in the bone density of the femoral neck in men in their 60s and in women in their 50s, suggesting that bone fragility may be generally less severe than before in Japan [22]. This is probably a result of increased body weight among Japanese individuals; increases in obesity, however, may result in decreases in hip fracture similar to the data described from Northern Europe. Therefore, risks of fracture other than bone fragility should be assessed to help explain the increase in the incidence in Japan. We reported that one significant preventive factor for distal radius fractures among Japanese individuals was the use of a futon (as opposed to a bed) [23]. We speculated that futon use helps to maintain some level of physical activity, resulting in a reduced risk of falls. Moreover, the overall decrease in physical activity of a Westernized lifestyle may explain the increase in fracture incidence among Japanese patients. Another explanation may



be that more seniors with poor health due to other conditions are being treated, which results in people living longer at a time when their risk of falling is considerably high.

The incidence of neck fracture is higher than that of trochanteric fracture in Northern European and African populations, whereas neck fracture is less common in Japanese populations [3, 13, 24, 25]. This study showed that an increasing number of patients in the Tottori prefecture are suffering neck fracture relative to trochanteric fracture; the increases in age-standardized incidence during the two decades for neck fracture was 115% in men and 101% in women, and those for trochanteric fracture were 46% and 70% respectively. On the other hand, a recent survey in Sweden showed that the neck-to-trochanteric fracture incidence ratio had leveled off [2]. Although the reason for these trends is uncertain, the neck-to-trochanteric fracture ratio in Japan is approaching values observed in Northern European populations.

Our study has some limitations, particularly with regard to the data collection. The method of data collection was consistent, and, as mentioned before, we checked patient enrollment in three monitoring hospitals [6]. Second hip fractures in the same patient during the observational period were not specifically identified in the present survey, which may have affected the result. Moreover, hip fracture patients living in the Tottori prefecture and treated outside the prefecture may have been missed during the registration. The number of such patients, however, is likely to be very small.

We conclude that the age- and gender-specific incidence of hip fracture in the Tottori prefecture of Japan has not plateaued as it has for populations in Northern Europe and North America. This presents a remarkable challenge to the Japanese health care system. An estimated 12 million patients have osteoporosis in Japan, and only 20–25% are being treated with anti-osteoporotic medication. Appropriate diagnosis and treatment of osteoporosis is essential, and more effective interventions for preventing falls are needed.

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**Conflicts of interest** None.

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